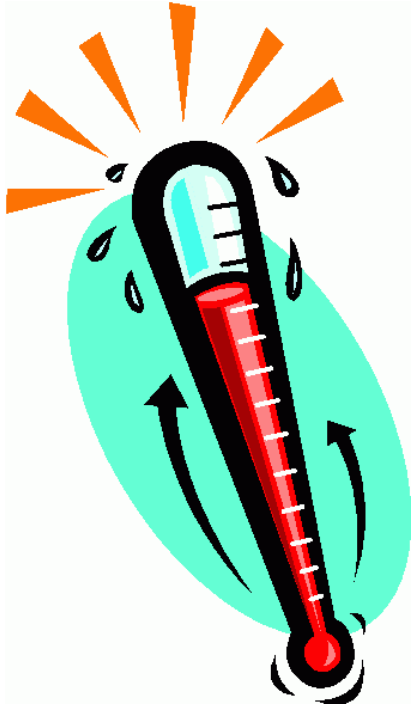


How does temperature affect fish?



Egg maturation/hatching

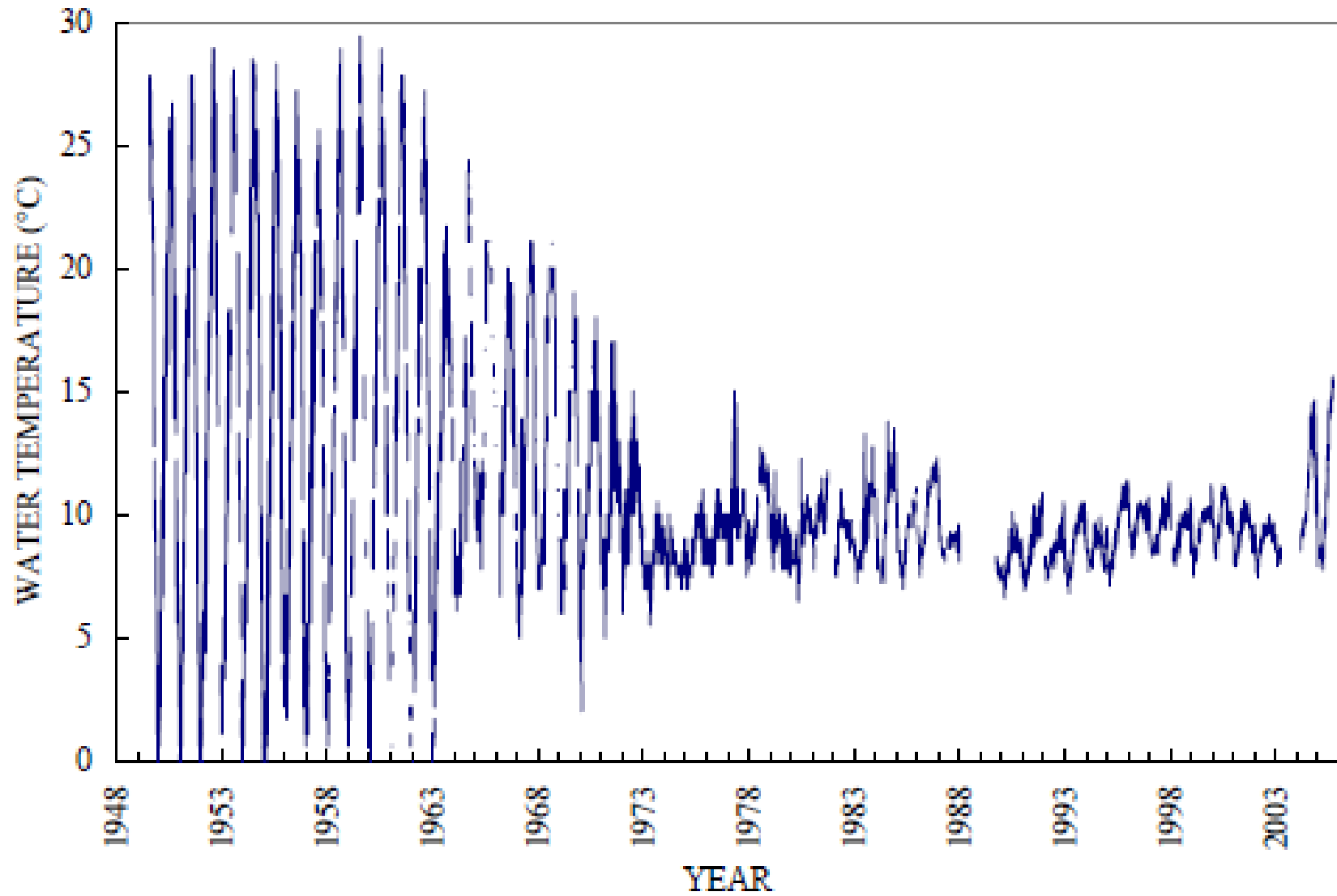
Growth

Swimming ability

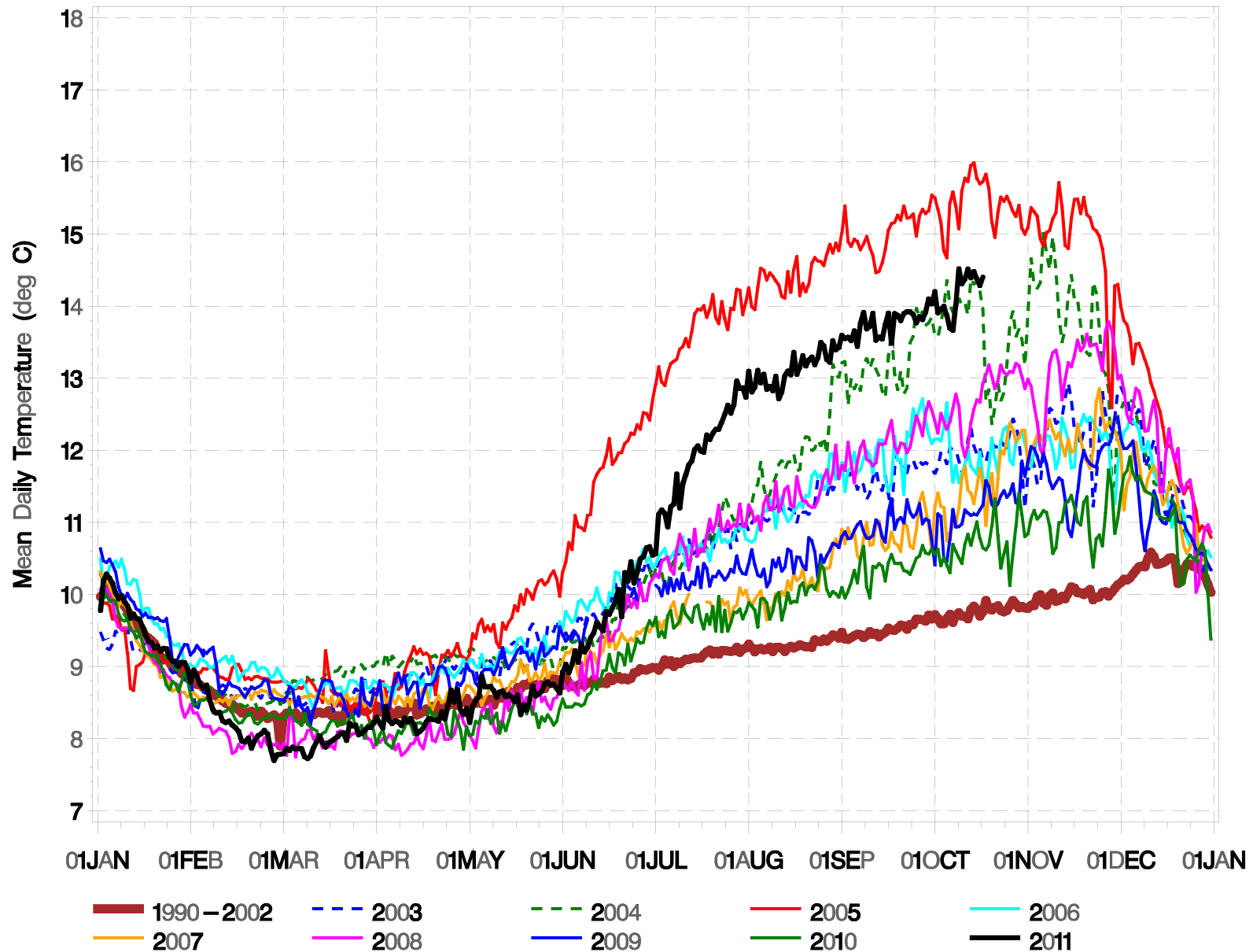
Predation vulnerability



Mainstem Colorado River Temperature



GCD Release Temperatures



Bill Vernieu, Provisional Data

Egg/larval survival



5 °C - 0 % survival of humpback chub embryos (Marsh 1985)

10 °C - 0 % survival of humpback chub embryos (Marsh 1985)

12 °C - 12 % hatching success and 15% larval survival (Hamman 1982)

16 °C - 62 % hatch success and 91% larval survival (Hamman 1982)

19 °C - 84 % hatch success and 95% larval survival (Hamman 1982)



June 20, 2010			December 2, 2010		Average Growth (mm)
Temperature °C	<u>Total Length (mm)</u>		<u>Total Length (mm)</u>		
	Mean	Range	Mean	Range	
12.5	50.5	(40 - 65)	52.8	(40 - 68)	2.3
20	50.5	(40 - 67)	72.3	(55 - 103)	21.8

166 days

0.4 mm/month in Cold Water

3.9 mm/month in warm water

D. Ward, Unpublished Provisional Data

Larval/Juvenile growth

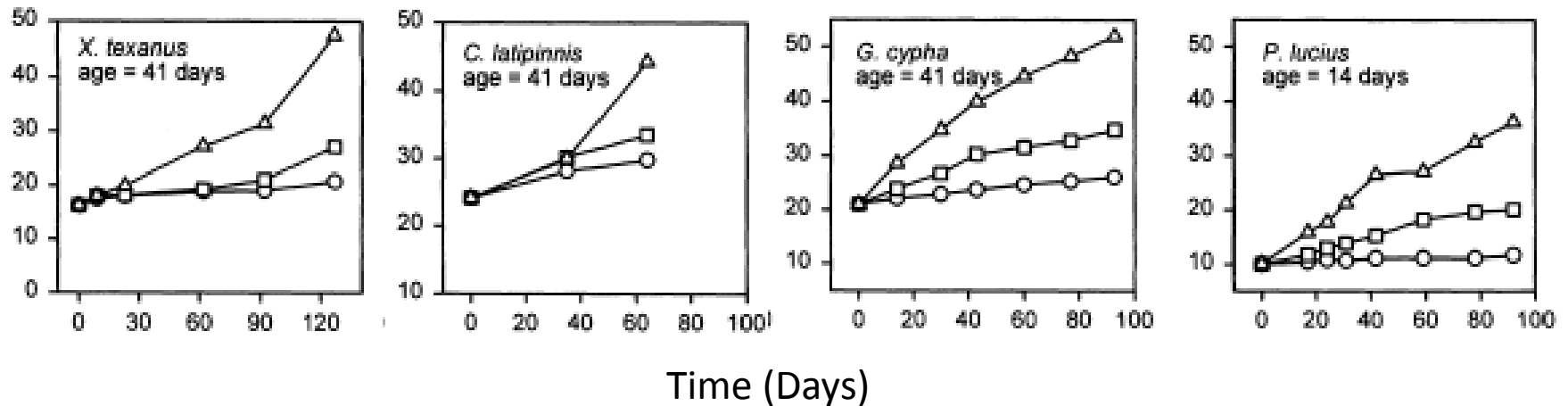
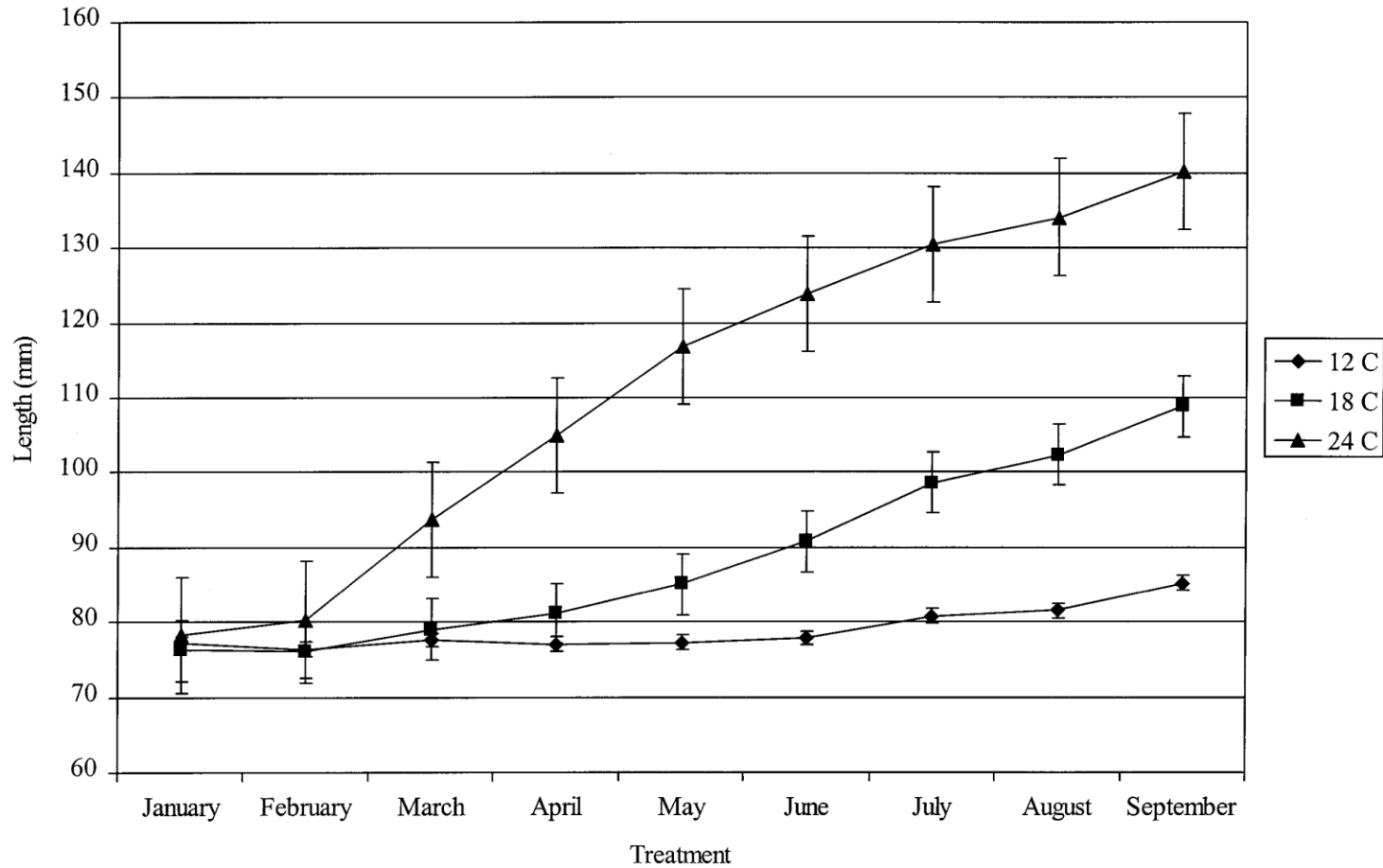


Figure 1. Changes in length (TL) over time for early life stages of big river fishes reared at three temperatures. Points represent mean responses of each species; ages are days post hatch at initiation of experiment. Circles denote 10 C, Squares 14 C and Triangles 20 C.

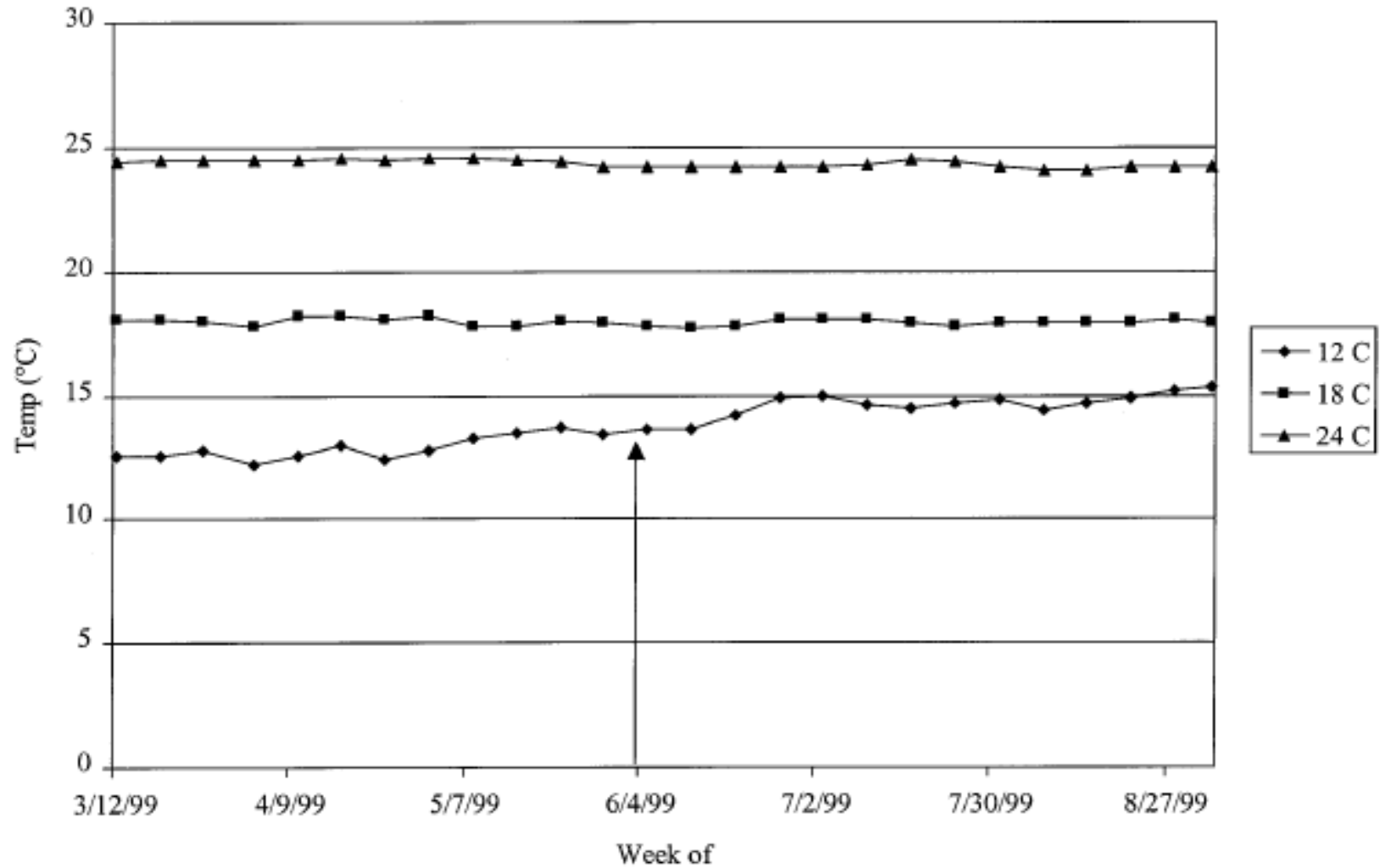
Juvenile growth

Figure 1. Humpback chub length with standard error bars

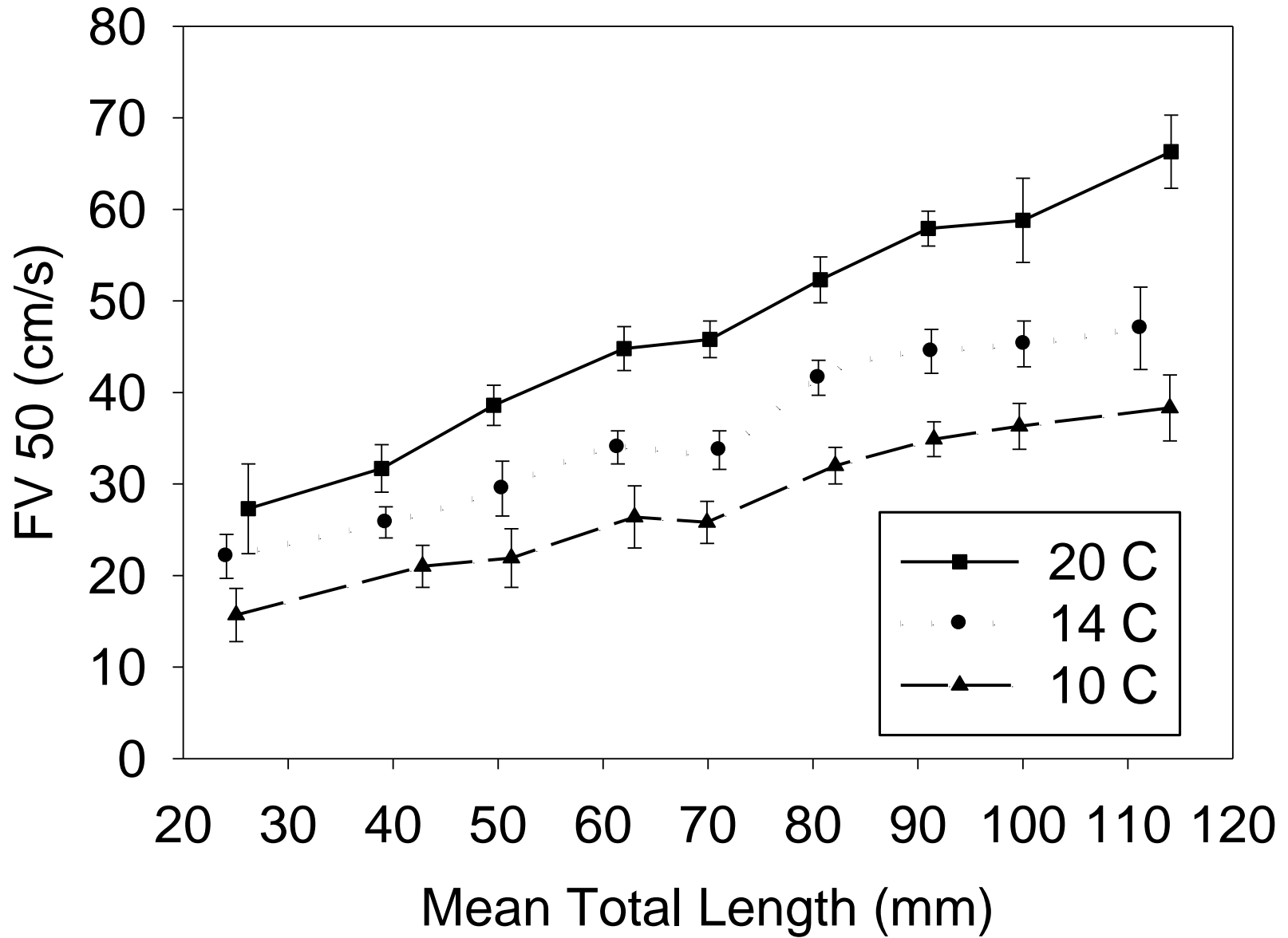


Gorman and Vanhoosen, 2000

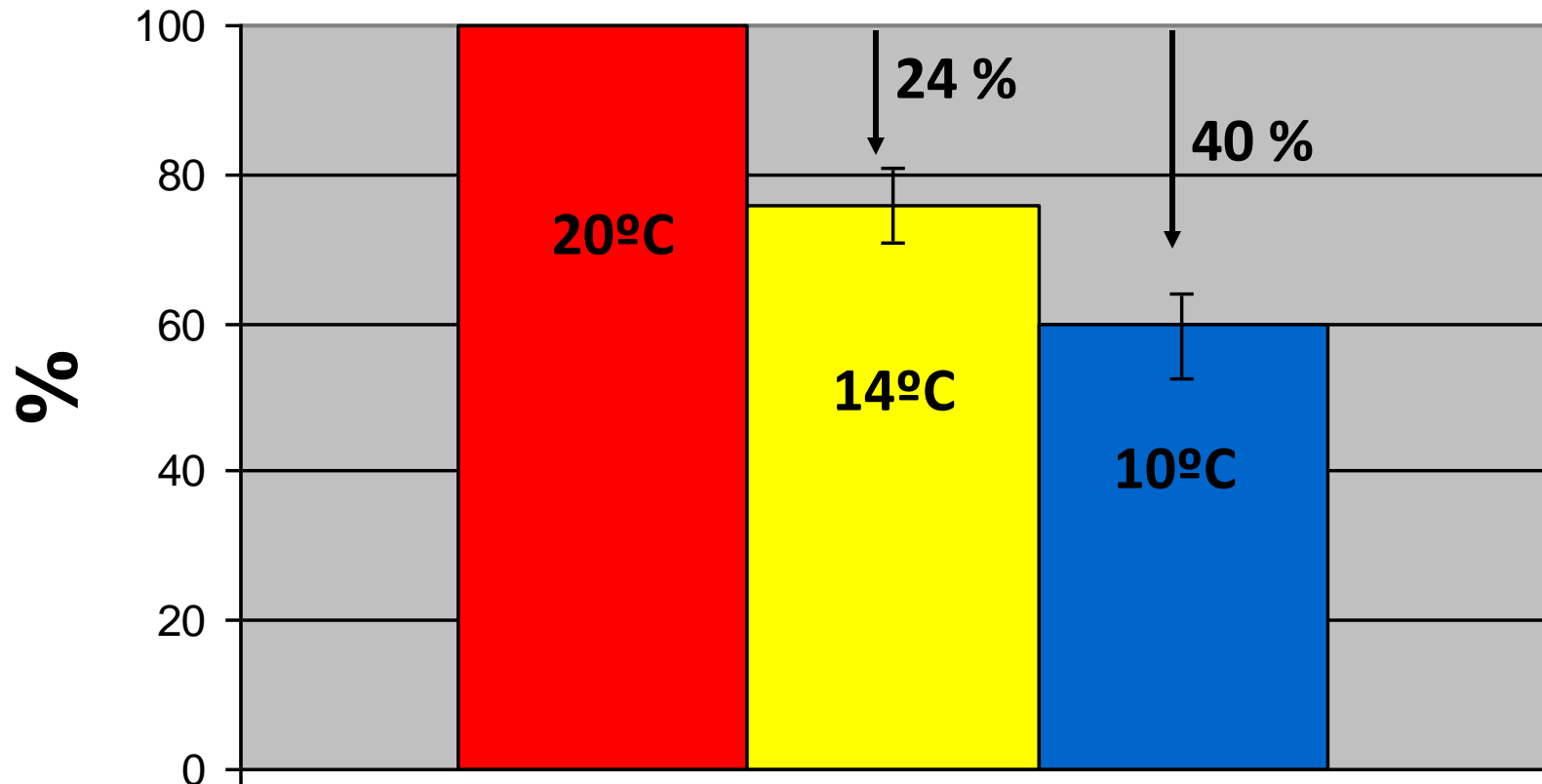
Figure 9. Temperatures in recirculating systems



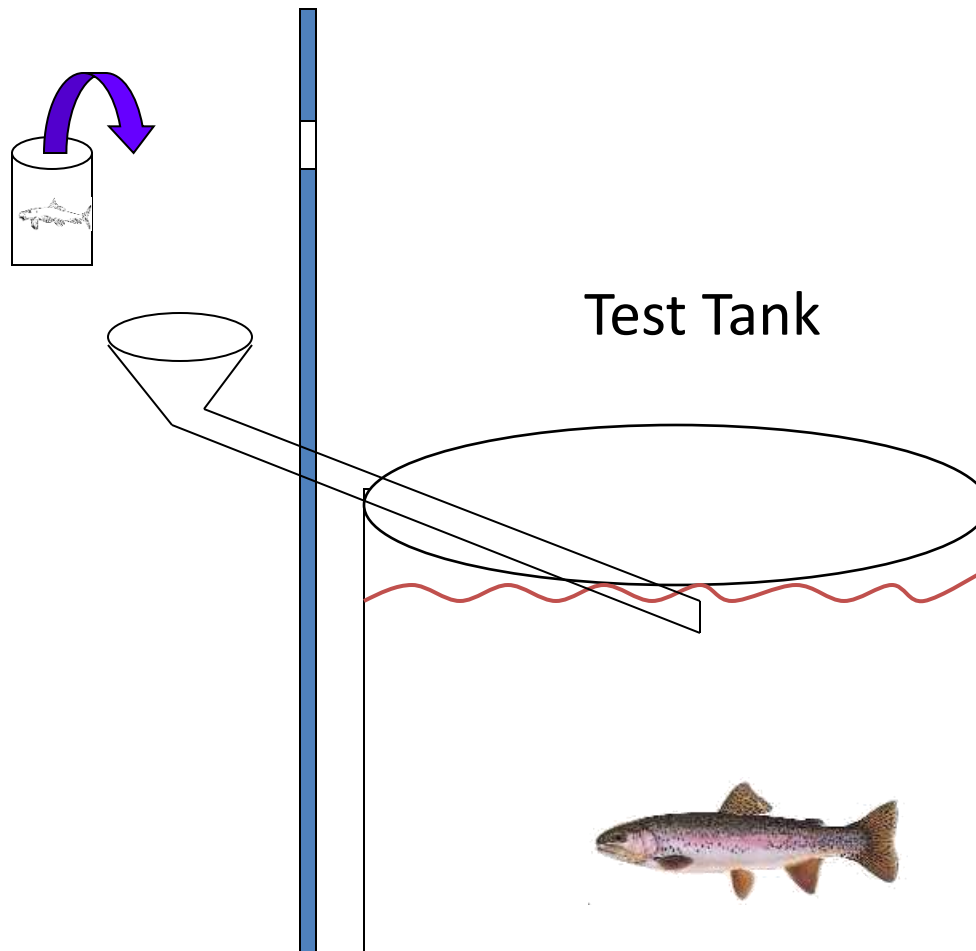
Swimming Ability



Average decrease in swimming ability at reduced temperatures



Predation Vulnerability



Two control trials (20°C) and two experimental trials (10°C)

Comparison of number of attacks versus number of prey consumed

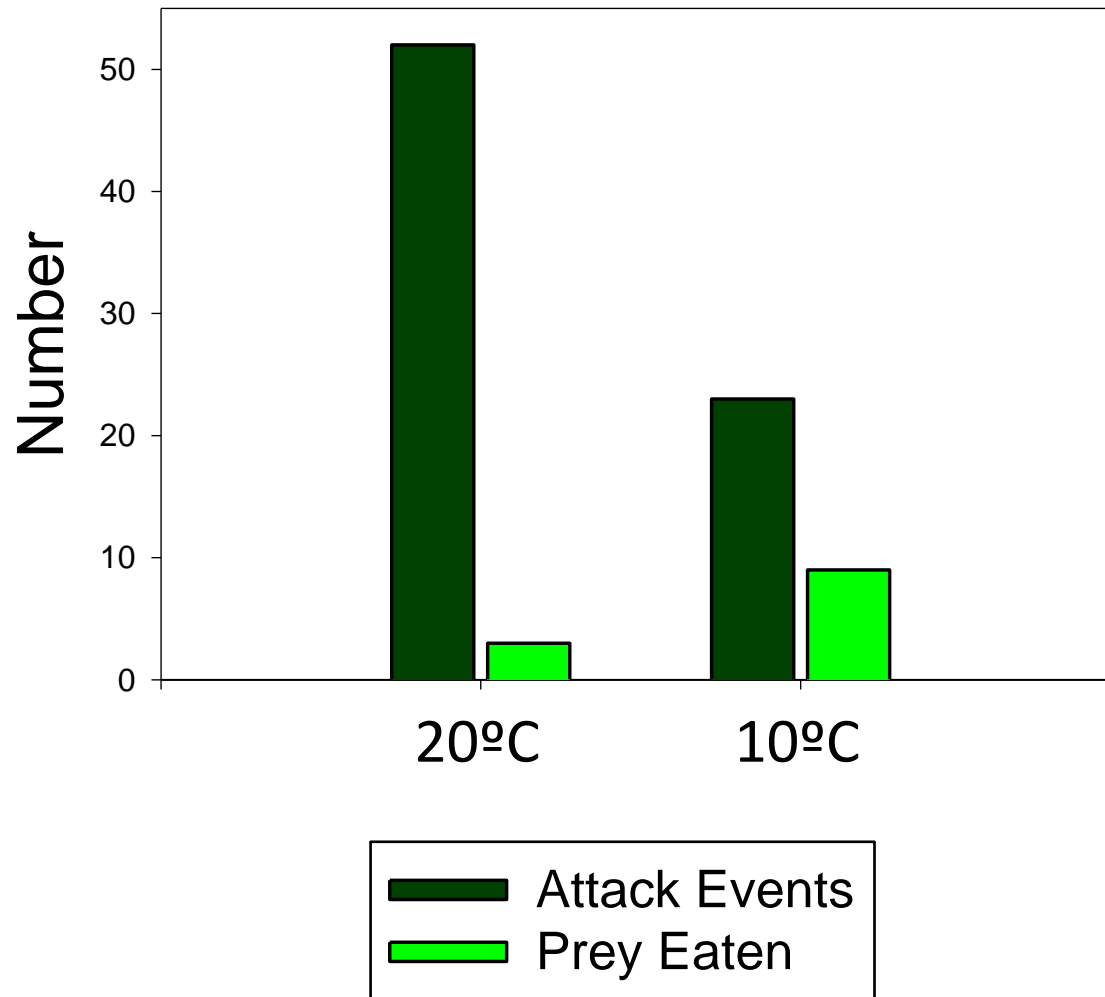


Table 1. Ability of flannelmouth sucker to escape predation by rainbow trout following an abrupt 10°C temperature change as measured by the number of attacks and number of prey consumed during 10-min predation tests.

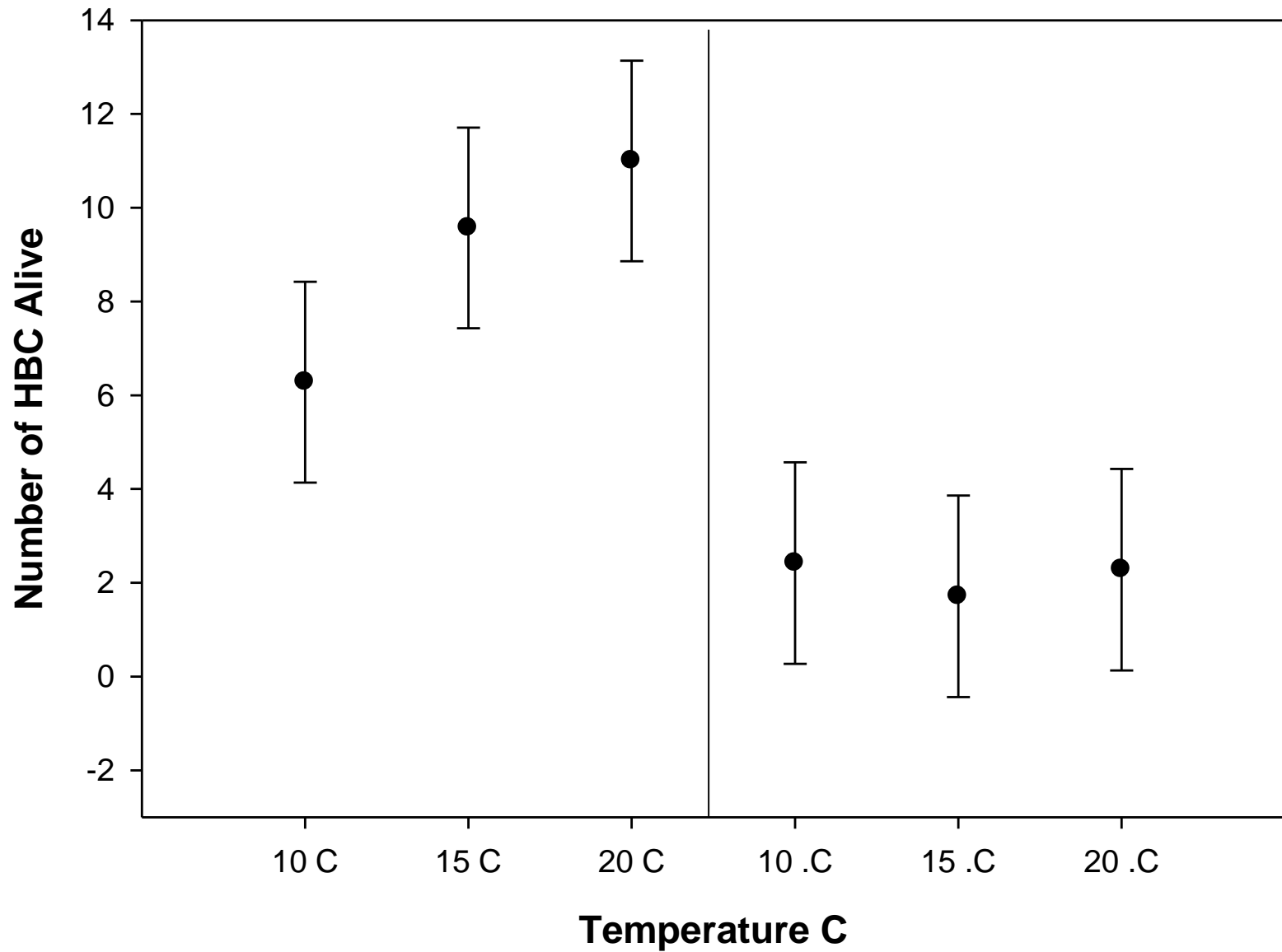
Temperature °C	Number of attacks	Number consumed	% Successful attacks
20	52	3	5.8
10	23	9	39.1





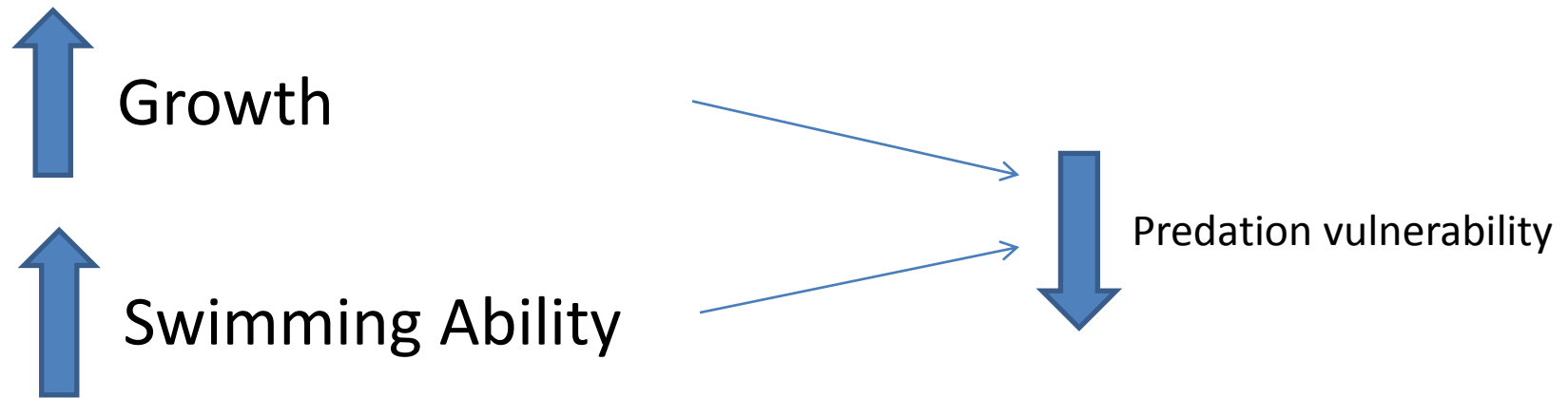
Rainbow Trout

Brown Trout



D. Ward, unpublished provisional data

Increased water temperature



How much increase in temperature is enough?